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**A Biological Assessment of Sites in the Clarks
Fork of the Yellowstone Watershed, Carbon
and Yellowstone Counties, Montana TMDL-Y05
August-September, 2003**

Bollman, W. 2004

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WATERSHED,
CARBON AND YELLOWSTONE COUNTIES, MONTANA**

TMDL-Y05

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A report to

**The Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Helena, Montana
Pat Newby, Project Officer**

by

**Wease Bollman
Rhithron Associates, Inc.
Missoula, Montana
February 2004**



INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations. This report summarizes data collected in August and September, 2003 from 4 sites; 2 sites were located on West Red Lodge Creek, and single sites were located on Red Lodge Creek and on the Clarks Fork of the Yellowstone River. Sites were located in Carbon and Yellowstone Counties, Montana, and lie within the Montana Valley and Foothill Prairies ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has studied the assemblages of the Montana Valley and Foothill Prairies (MVFP) ecoregion and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples. It may not, however, be appropriate for assessing high order, riverine locations such as the Clarks Fork of the Yellowstone near its mouth. Assessment of that site is given cautiously.

METHODS

Samples were collected in August and September, 2003 by personnel of the Montana Department of Environmental Quality (Montana DEQ). Sample designations and site locations are indicated in Table 1 and on Figure 1. The site selection and kicknet sampling method employed were those recommended in the Montana DEQ Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses. In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1. Sample designations and locations. Sites are listed in upstream-to-downstream order. Clarks Fork of the Yellowstone watershed. August-September, 2003.

Site ID	Station ID	Activity ID	Location Description	Collection Date	Latitude	Longitude
RDLWC 10	Y05RDLWC10	03-Y541-M	West Red Lodge Creek above Luther Road Bridge	8/8/03	45°-17'-02"	109°-25'-49"
RDLWC 20	Y05RDLWC20	03-Y542-M	West Red Lodge Creek above lowermost bridge	8/9/03	45°-19'-16"	109°-19'-11"
RDLGC 40	Y05RDLGC40	03-Y594-M	Red Lodge Creek above lowest bridge above Cooney Reservoir	9/18/03	45°-25'-11"	109°-17'-35"
CFYR9 99	Y05CFYR999	03-Y610-M	Clarks Fork of the Yellowstone near the mouth	8/21/03	45°-39'-00"	108°-42'-53"

To assess aquatic invertebrate communities, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used for MVFP sites in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the Clarks Fork of the Yellowstone drainage. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. Ephemeroptera (mayfly) taxa richness. The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. Plecoptera (stonefly) taxa richness. Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of

morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. Trichoptera (caddisfly) taxa richness. Caddisfly taxa richness has been shown to decline when sediment deposition affects habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. Number of sensitive taxa. Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).

5. Percent filter feeders. Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery. The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 2. Metrics and scoring criteria for bioassessment of montane streams of Western Montana (Bollman 1998a).

Metric	Score			
	3	2	1	0
Ephemeroptera taxa richness	> 5	5 - 4	3 - 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 - 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 - 5	5.01 - 10	10.01 - 35	> 35

Table3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water

quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).

- **Taxa richness.** This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- **Percent predators.** Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- **Number of "clinger" taxa.** So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- **Number of long-lived taxa.** Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

RESULTS

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled from the Clarks Fork of the Yellowstone drainage. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b above show criteria for impairment classifications (Plafkin et al. 1989) and use-support categories recommended by Montana DEQ (Bukantis 1998).

When this method is applied to these data, scores suggest that the uppermost site on West Red Lodge Creek (RDLWC10) was slightly impaired but fully supported designated uses. Above the lowermost bridge, the West Red Lodge Creek site (RDLWC20) was slightly impaired and partly supported uses. Above the Cooney Reservoir, Red Lodge Creek (RDLGC40) was moderately impaired and partly supportive of designated uses. The site on the Clarks Fork of the Yellowstone River near the mouth (CFYR999) was slightly impaired and uses were partly supported there.

Figure 2. Comparison of total bioassessment scores (reported as percent of maximum score) for 4 sites on the Clarks Fork of the Yellowstone drainage. August-September, 2003. The revised bioassessment method (Bollman 1998a) was used to calculate scores.

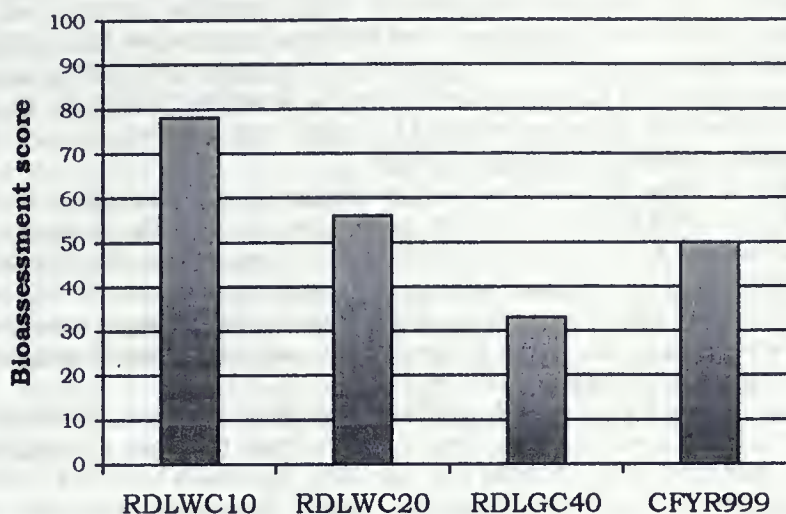


Table 5. Metric values, scores, and bioassessments for 4 sites on the Clarks Fork of the Yellowstone drainage. August-September, 2003. Site locations are given in Table 1. The revised bioassessment method (Bollman 1998a) was used to calculate scores.

	SITES			
	RDLWC10	RDLWC20	RDLGC40	CFYR999
METRICS	METRIC VALUES			
Ephemeroptera richness	7	7	4	8
Plecoptera richness	3	1	1	1
Trichoptera richness	8	6	5	4
Number of sensitive taxa	2	2	0	0
% filterers	0.91	27.44	26.83	9.15
% tolerant taxa	11.18	24.29	48.17	28.96
	METRIC SCORES			
Ephemeroptera richness	3	3	2	3
Plecoptera richness	2	1	1	1
Trichoptera richness	3	3	3	2
Number of sensitive taxa	2	2	0	0
% filterers	3	0	0	2
% tolerant taxa	1	1	0	1
TOTAL SCORE (max.=18)	14	10	6	9
PERCENT OF MAX.	78	56	33	50
Impairment classification*	SLI	SLI	MOD	SLI
USE SUPPORT †	FULL	PART	PART	PART

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.† Use support designations: See Table 3a.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

Two sites on West Red Lodge Creek were sampled for invertebrates. Above the Luther Road bridge (RDLWC10), 7 mayfly taxa were collected in the sample. The biotic index value calculated for the entire sampled assemblage was 1.98. These findings suggest that water quality was good at this site; nutrients apparently did not substantially influence the composition of the benthic invertebrate community. Two sensitive cold-stenotherm taxa were present in the sample, suggesting that cold water temperatures were characteristic of the site.

Nineteen "clinger" taxa and 8 caddisfly taxa were counted. Sediment deposition probably did not limit access to stony benthic substrate habitats. Overall taxa richness (36) was high, likely reflecting diverse and available instream habitats. Stonefly taxa richness was somewhat lower than expected; only 3 Plecoptera taxa were taken. Low numbers of stonefly taxa may be associated with disturbance of reach scale habitat features, such as streambanks, channel morphologic elements, and riparian zones. Semivoltine taxa were represented by 5 species, making it seem unlikely that dewatering, scouring sediment pulses, or other catastrophic events interrupted long life cycles here. The functional mix was dominated by scrapers, such as *Agapetus* sp. and *Optioservus* sp. Abundant scrapers suggests that riparian shading was limited.

Above the lowermost bridge, the West Red Lodge Creek site (RDLWC20) supported at least 7 mayfly taxa, but the biotic index value (4.18) was higher than expected. Mild nutrient enrichment may be indicated; this hypothesis is supported by the dominance of tolerant taxa, such as *Optioservus* sp. and *Simulium* sp., collected here. A single cold-stenotherm taxon was collected, but was not abundant. Water temperatures may have been somewhat warmer than typical for a foothill stream.

Both "clinger" taxa (19) and caddisfly taxa (6) were well-represented at the site, suggesting that stony substrates were largely free from sediment deposition. High taxa richness (35) implies the availability of diverse undisturbed instream habitats. A few stoneflies in a single taxon (*Hesperoperla pacifica*) were present in the sample. Unstable streambanks, altered channel morphology, or disrupted riparian zones may be associated with low stonefly taxa richness. Five long-lived taxa were collected, implying year-round surface flow. The functional composition of the sampled assemblage included all expected elements.

Above the Cooney Reservoir, the sampled site on Red Lodge Creek (RDLGC40) exhibited lower than expected mayfly taxa richness (4) and an elevated biotic index value (4.10). These findings suggest that water quality may have been impaired at this site. Given the taxonomic composition of the sampled assemblage, thermal stress seems to be the likely cause of the marginal performance of the water quality indicator metrics. The dominant taxon, the caddisfly *Helicopsyche borealis*, prefers relatively warm water temperatures, and no cold-stenotherms were counted among the sampled animals.

Although caddisfly taxa richness (6) was within expected limits at this site, the number of "clinger" taxa taken in the sample was low. Impairment of benthic habitats by sediment deposition cannot be ruled out. Overall taxa richness (25) was marginal; instream habitats may have been limited, and substrates monotonous. A single specimen of *Claassenia sabulosa* made up the entire stonefly fauna collected here. The dearth of stonefly taxa could be associated with disturbance to riparian zone function,

altered channel morphology, or streambank instability. Four long-lived taxa were collected at this site, but none was abundant; three of the 4 taxa were represented by single individuals. Dominant among the functional components of the assemblage were scrapers, implying a lack of riparian shading. All other expected functional elements were present at the site.

Near its mouth, the Clarks Fork of the Yellowstone (CFYR999) supported an assemblage characteristic of valley riverine environs. Mayflies such as *Choroterpes* sp., *Camelobaetidi* sp, and *Traverella* sp. are typical of such locations. These were 3 of the 8 mayfly taxa collected at this site. This high mayfly taxa richness was consistent with the low biotic index value (2.53) calculated for the sampled assemblage as a whole; together these findings suggest that water quality was good at this site. Thermal conditions implied by the taxonomic composition of the sample seem entirely appropriate for a high order stream.

Metrics developed for low order streams and used for the other sites in this study may not be applicable to conditions at the mouth of the Clarks Fork of the Yellowstone. However, some sediment deposition may be indicated by the low number of "clinger" taxa. Stonefly taxa richness is probably not a good indicator of reach scale features for a riverine setting. The functional composition of the benthic assemblage was overwhelmed by gatherers.

CONCLUSIONS

- Good water quality and adequate instream habitats appear to be indicated by the composition of the benthic fauna at the upper site on West Red Lodge Creek (RDLWC10). Reach scale habitat features, especially riparian zones, may have been disturbed.
- Mild nutrient enrichment was suggested by the overall tolerance of the invertebrate assemblage at the lower site on West Red Lodge Creek (RDLWC20), and by the dominance of *Optioservus* sp. and *Simulium* sp. Reach scale habitat features may have suffered disturbance as well.
- The taxonomic composition of the sample collected from Red Lodge Creek above the Cooney Reservoir suggests that thermal stress impairs biotic integrity in this reach. Sediment deposition and disturbance of reach scale habitat features may further challenge benthic assemblages here.
- Good water quality appears to be indicated by the large number of mayfly taxa present at the mouth of the Clarks Fork of the Yellowstone (CFYR999). Metrics devised and tested for lower order streams may not be appropriate tools for the assessment of a high order system such as this.

Habitat Assessment

Figure 3 graphically compares total habitat assessment scores recorded for the 3 sites in this study. Table 5 shows the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied.

All instream, streambank, channel, and riparian habitat parameters were given optimal or sub-optimal scores at the upstream site on West Red Lodge Creek (RDLWC10). Overall conditions scored optimally. Downstream, at the lowermost bridge on West Red Lodge Creek (RDLWC20), overall habitat conditions were judged sub-optimal. Streambanks were perceived to be moderately unstable, and the riparian zone was abbreviated. Above the Cooney Reservoir, the site on Red Lodge Creek (RDLGC40) scored sub-optimally. Monotonous benthic substrate was appraised, and streambanks were noted to be unstable, with bank vegetation disrupted. The riparian zone width was less than ideal. At the mouth of the Clarks Fork of the Yellowstone, embedded benthic substrate was reported, and the riparian zone width was perceived to be abbreviated. Overall habitat conditions scored sub-optimally.

Figure 3. Total habitat assessment scores for sites on the Clarks Fork of the Yellowstone drainage. August-September, 2003

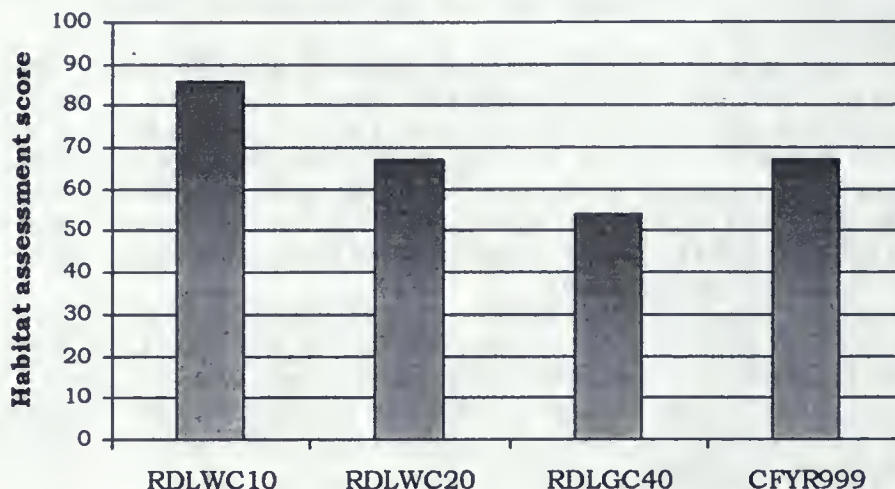


Table 5. Stream and riparian habitat assessment. Sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. The Clarks Fork of the Yellowstone drainage, August-September, 2003.

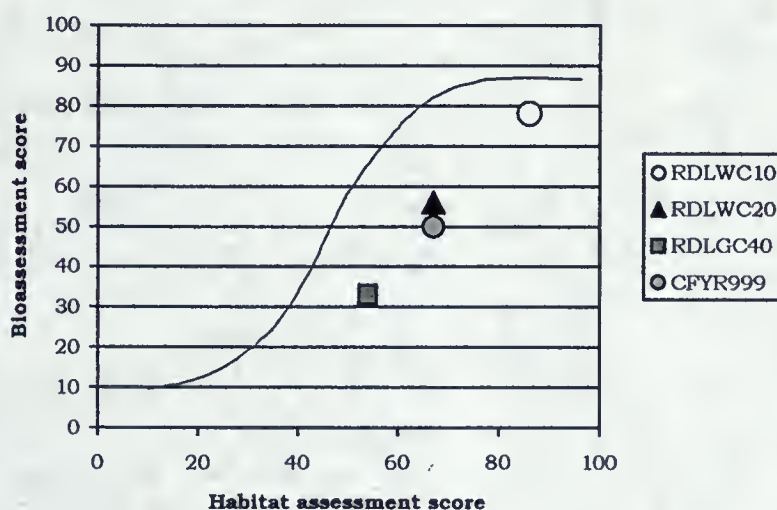
Max. possible score	Parameter	SITES			
		RDLWC10	RDLWC20	RDLGC40	CFYR999
10	Riffle development	10	9	9	9
10	Benthic substrate	7	6	5	5
20	Embeddedness	16	11	11	10
20	Channel alteration	16	16	15	15
20	Sediment deposition	20	15	12	15
20	Channel flow status	20	18	15	15
20	Bank stability	8 / 8	5 / 5	3 / 3	7 / 7
20	Bank vegetation	8 / 8	7 / 7	4 / 4	7 / 7
20	Vegetated zone	8 / 8	4 / 4	3 / 3	5 / 5
160	Total	137	107	87	107
	Percent of maximum	86	67	54	67
	CONDITION*	opt	sub	sub	sub

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Habitat assessment vs. bioassessment

When habitat assessment scores are plotted against bioassessment scores, the resulting figure provides an opportunity to evaluate the hypothetical relationship between habitat integrity and water quality. Both factors are critical and interactive determinants of the composition and functional integrity of aquatic invertebrate assemblages. Presumably, high quality habitat, in the absence of impairments to water quality, supports functional, diverse, and sensitive invertebrate assemblages; these are assemblages that attain high bioassessment scores. Barbour and Stribling (1991) have hypothesized that diminishing habitat quality should produce predictable diminishment of bioassessment scores, when water quality is not a further insult. Figure 4 is a plot of habitat assessment scores against bioassessment scores (revised method) for the sampled assemblages of the Clarks Fork of the Yellowstone drainage. The red line superimposed on the plot represents the hypothetical relationship between habitat quality and biotic integrity given good water quality. In this model, symbols falling in the upper right area of the graph would represent sites with high scores for both bioassessment and habitat assessment; according to this model, these would be unimpaired sites both in terms of habitat integrity as well as water quality. The plot in Figure 4 locates the upstream site on West Red Lodge Creek (RDLWC10) in this area. Some degree of habitat degradation is hypothesized for sites located along the downward progression of the red line, that is, when bioassessment scores are falling predictably with decreasing habitat scores. When habitat scores remain high, but bioassessment scores are inordinately low, sites fall into the lower right hand quadrant of the plot. According to the model, these sites support invertebrate assemblages that are impacted mostly by impairment to water quality. Following that, the lower site on West Red Lodge Creek (RDLWC20), the site on Red Lodge Creek (RDLGC40), and the site on the Clarks Fork of the Yellowstone (CFYR999) appear to be influenced by both water quality impairment and habitat disturbance, judging by the relationship between habitat assessment scores and bioassessment scores for these sites.

Figure 4. Total bioassessment scores plotted against habitat assessment scores for sites on the Clarks Fork of the Yellowstone drainage. August-September, 2003. (Barbour and Stribling 1991).



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